

CALIFORNIA DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-115

April 10, 1981

1. Name of fault

Calaveras fault zone, Mission fault, <sup>and</sup> San Felipe fault (figure 1).

2. Location of fault

La Costa Valley, Calaveras Reservoir, San Jose East, Mt. Day, and Lick Observatory 7.5-minute quadrangles, Alameda and Santa Clara Counties.

3. Reason for evaluation

Part of 10-year fault evaluation program (Hart, 1980).

4. References

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- National Oceanic and Atmospheric Administration, 1977, Results of triangulation for earth movement study at California Aqueduct-fault crossing sites; Section VI: North and South San Francisco Bay Aqueducts, Supplement No. 6 - UNION and VERAS sites.
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5. Review of available data and air photo interpretation

Calaveras Fault Zone

The Calaveras fault zone evaluated in this Fault Evaluation Report (FER) is a complex, distributive zone of right-lateral strike-slip faulting (figures 2a, b, c). Land surfaces along the fault zone throughout most of the FER study area have not been modified by man. However, relatively high relief in most of the FER study area results in rates of erosion that generally exceed rates of fault offset. Massive landsliding and lateral spreading<sup>9</sup> also obscure fault traces. Thus, detailed geomorphic features indicating right-lateral strike-slip offset during Holocene time are sparse.

The Calaveras fault zone in the FER study area is located within the La Costa Valley, Calaveras Reservoir, and Lick Observatory 7.5-minute quadrangles (figures 2a, b, c). Segments of the Calaveras fault zone in the Mt. Day and San Jose East quadrangles are included on figures 2b and 2c, respectively. The Calaveras fault zone shown in figures 2a, 2b, and 2c was zoned for special studies in 1974. This <sup>of the existing 1974 SSZ in the La Costa Valley, Calaveras Reservoir, San Jose East</sup> FER is a re-evaluation of Mt. Day and Lick Observatory quadrangles.

The Calaveras fault depicted on the 1974 Special Studies Zones Map of the La Costa Valley 7.5-minute quadrangle is based on mapping by Cotton (1972), Hall (1958), and Levish (1973, p.c.). (figure 2a). The Calaveras fault is well-defined at the very southern part of the La Costa Valley quadrangle and in the northwest part of the quadrangle north and south of Scotts Corner, but geomorphic evidence of Holocene

faulting is generally vague between these segments and is often concealed by landsliding along the east side of Sunol Valley (figure 3a). Sunol Valley is bounded on both the east and west sides by traces of the Calaveras fault (figure 2a). Levish (1973, p.c.) maps the west branch Calaveras fault as approximately located along the west side of Sunol Valley (figure 2a). Levish probably based the location of the west branch Calaveras fault on the faceted ridge spurs along the west side of the valley, but his mapping is not adequately documented in CDMG files. The linear, truncated ridge spurs in Cretaceous bedrock may be the result of faulting along the west side of Sunol Valley, but an erosional origin cannot be ruled out. Specific geomorphic evidence indicating Holocene faulting was not observed along most of the west side of Sunol Valley, based on Herd (1978) and limited air photo interpretation by Hart (written communication, 1979, 1981) (figure 3a). Possible Holocene faulting along the west side of Sunol Valley near Haynes Gulch is indicated by a right-laterally deflected drainage and a linear tonal contrast on a late-Pleistocene terrace deposit (figure 3a). Herd (1978) maps the west branch of the Calaveras fault as concealed by Holocene alluvium and late-Pleistocene(?) terrace deposits (Helley and others, 1972). Hall (1958) does not map a fault along the west side of Sunol Valley.

The east branch Calaveras fault of Levish (1973, p.c.) is well defined north and south of Scotts Corner, but geomorphic evidence of Holocene faulting along branch fault A of Levish was not observed by Hart (1979, p.c.) (figure 2a). Geomorphic evidence indicating Holocene faulting was observed by Herd (1978) and Hart just north of Scotts Corner. Subtle northeast facing scarps associated with a right-laterally offset drainage and linear trough delineate the Calaveras fault at this location (figure 3a).

Fault traces of Herd (1978), Hart, and Levish generally agree south of Scotts Corner to Hetch Hetchy Aqueduct, but differences in detail exist (figure 2a, 3a). South of Hetch Hetchy Aqueduct to about the center of section 11, T5S, R1E, traces

of the Calaveras fault are generally not well-defined and are obscured by massive landsliding (figure 3a).

Hall (1958) maps the east branch Calaveras fault as concealed from section 34, T4S, R1E, south to the NW 1/4 section 11, T5S, R1E (figure 2a). Geomorphic evidence permissive of Holocene faulting along this segment of the Calaveras fault was observed by Hart (1981, p.c.) and this writer, and is characterized by a linear trough, vague tonal contrasts, and deflected drainages defining short, discontinuous fault traces (figure 3a).

South of section 11, T5S, R1E the main trace Calaveras fault is delineated by a well-defined linear trough with associated scarps, closed depressions, right-laterally deflected drainages, and tonal contrasts in Holocene alluvium of Dibblee (1980) (figure 3a). Cotton (1972) maps a segment of the Calaveras fault at this location, but differences in detail exist between Cotton, Herd (1978), Dibblee (1980) and this writer (figures 2a, 3a). Cotton's and Dibblee's fault trace east of the main trace Calaveras fault (branch fault B) is not well-defined (figure 2a).

Evidence of historic fault creep along the Calaveras fault occurs in the La Costa Valley quadrangle about 2000 feet southeast of Scotts Corner (figure 2a, 3a). A triangulation net (VERAS) installed by NOAA in 1965 has been periodically resurveyed. An average fault creep rate of 2 to 3 mm/yr has been observed during the period 1970 to 1976 (NOAA, 1977). The triangulation net crosses the main trace of the Calaveras fault that is characterized principally by linear, SW-facing truncated spurs along the east side of Sunol Valley (Herd, 1978) (figure 3a).

The Calaveras fault zone depicted on the 1974 SSZ Maps of the Calaveras Reservoir quadrangle and a portion of the Mt. Day quadrangle is based on mapping by Cotton (1972), Dibblee (1973), Levish (p.c., 1974) and Radbruch (1968) (figure 2b). A later map by Radbruch-Hall (1974) is the same as Radbruch's 1968 map. Traces of the Calaveras fault mapped by Radbruch (1968) essentially are from Crittenden (1951), except for a segment mapped in the Upper Penitencia Creek and Cherry Flat Reservoir areas (figure 2b).

The Calaveras fault zone shown on the 1974 SSZ Map of the Calaveras Reservoir quadrangle is a wide and complex zone of faulting. The west branch Calaveras fault of Dibblee (1973) is based primarily on Crittenden (1951) (figure 2b). This fault forms a major lithologic contact between Cretaceous Berryessa Formation to the west and Franciscan Formation to the east. However, there is no geomorphic evidence of Holocene faulting from the NW 1/4 of section 17, T6S, R2E south along Crittenden's and Dibblee's trace of the west branch Calaveras fault (figure 2b). Upper Penitencia Creek is not offset where the fault trace crosses the creek and other minor drainages that cross the fault are not offset or deflected in a right-lateral or vertical sense (figure 2b).

Geomorphic evidence of Holocene faulting along the west branch Calaveras fault of Cotton (1972) was not observed, based on air photo interpretation by this writer (figure 2b). Minor drainages that cross the fault trace are not offset. The right lateral deflection of Upper Penitencia Creek is not sharp and may be <sup>deflected by landsliding</sup> ~~erosional~~ (figure 2b). Well-defined benches of the east side of Arroyo Aguague are mapped by Nilsen (1972) as landslides (figure 2b). Cotton locates the west branch Calaveras fault east of the ridge, but geomorphic evidence of faulting was not observed by this writer.

Herd (in press) maps late Quaternary traces of the Calaveras fault in the Calaveras Reservoir quadrangle (figure 2b). In the northern part of the quadrangle Herd maps a well-defined fault trace characterized by linear drainage with associated W-facing ~~scarp~~ <sup>scarp</sup> and linear trough extending north into the La Costa Valley quadrangle (figure 2a, 2b). Calaveras Reservoir covers the probable main trace of the Calaveras fault. Herd maps a fault trace about 2,000 feet east of the reservoir that is characterized by saddles and possible back-facing scarps (figure 2b, 3b). However, Dibblee (1973) maps a lithologic contact between Franciscan shale (sheared) and Franciscan sandstone (greywacke and shale). Bedding strikes parallel to the fault mapped by Herd (in press). Systematically offset drainages, closed

depressions, or other geomorphic evidence of Holocene faulting, rather than erosion along contrasting lithology, was not observed by this writer, based on air photo interpretation. However, bedding plane faulting cannot be dismissed.

South of Calaveras Reservoir the east branch Calaveras fault is probably the main active trace of the Calaveras fault. Mapping by Crittenden (1951), Dibblee (1973), Radbruch (1974) and this writer (figure 3a) agree in general, but differences in detail exist. Upper Penitencia Creek has been right laterally offset about 5,000 feet along the Calaveras fault near Cherry Flat Reservoir (figures 2b, 3b). A behead<sup>ed</sup> drainage just west of Cherry Flat Reservoir may connect with a drainage southeast<sup>in the</sup> of Mt. Day quadrangle, suggesting about 5,500 feet of right-lateral offset (figure 3b). Detailed geomorphic evidence of Holocene faulting along the east branch Calaveras fault in the Upper Penitencia Creek - Cherry Flat Reservoir area has been modified or obscured by large scale landsliding and rapid stream erosion (Nilsen, 1972; figure 3b).

Geomorphic evidence permissive of faulting northwest of Upper Penitencia Creek along the trace of the east branch Calaveras fault consists of linear drainages, troughs, and deflected drainages (both right and left lateral) (figure 3b). The steep terrain and associated rapid erosion, plus the generally unstable slopes result in the destruction of small-scale geomorphic features normally developed by surface fault rupture.

The Calaveras fault zone depicted on the SSZ Maps of the Lick Observatory and a portion of the San Jose East quadrangles is based on mapping by Cotton (1972), Dibblee (1972a, 1972b), and Radbruch (1968) (figure 2c). A more recent map by Radbruch-Hall (1974) depicts the Calaveras fault the same as the 1968 map.

The west branch Calaveras fault of Dibblee (1972a, 1972b) generally is based on mapping by Crittenden (1951) (figure 2c). Although this fault is a major lithologic contact between Cretaceous Berryessa Formation and Franciscan Formation, geomorphic evidence of Holocene faulting was not observed by this writer, based on air photo interpretation (figure 2c). Holocene deposits are not offset along the trace of

this fault (Dibblee, 1972a) (figure 2c). Geomorphic evidence of Holocene faulting was not observed along the west branch Calaveras fault of Cotton (1972) (Arroyo Aguague fault of Dibblee, 1973, 1972b), based on air photo interpretation by this writer (figure 2c).

Well-defined fault traces permissive of Holocene faulting mapped by Herd (in press) and this writer (figure 3c) agree in general with the east branch Calaveras fault of Dibblee (1972) in the northern part of the Lick Observatory quadrangle north of Halls Valley (figure 2a, 3c). Southeast of Halls Valley, geomorphic evidence of Holocene faulting along Dibblee's east branches of the Calaveras fault were not observed by Herd (in press) or this writer (figure 2c).

The main trace Calaveras fault may step to the west between Halls Valley and San Felipe Valley (figures 2d, 3c). Well-defined traces of the Calaveras fault just south of San Felipe Valley are characterized by sidehill troughs, closed depressions, right laterally deflected and offset drainages, and beheaded drainages (figures 2c, 3c). The San Felipe fault of Dibblee (1972a) and Cotton (1972) and the short fault trace of Radbruch (1968) do not have geomorphic evidence of offset during Holocene time (figure 2c). Herd (in press) did not observe evidence of Holocene or late Quaternary faulting along the San Felipe fault (figure 2c).

Earth Science Associates (ESA) (1981) mapped air photo lineaments along the Calaveras fault zone, including the FER study area.

The Calaveras fault zone depicted by ESA in the FER study area is characterized by many inferred fault traces in a complex zone up to 9,000 feet wide. The air photo lineaments have not been field checked and a critical evaluation of the age of the features is not apparent. Mapping by ESA (1981) will not be evaluated in FER-115 due to very limited time constraints.

Several AP site investigations have been conducted in the FER study area (La Costa Valley quadrangle: AP-1185; Calaveras Reservoir quadrangle: AP numbers 303, 614, 770, 932, 965, 966, 967, 1234; San Jose East quadrangle: AP numbers 346, 546). The site investigations generally are inconclusive, con-

sisting of geophysical surveys without subsurface exploration, with the exception of AP-1185 near Scotts Corner (figure 2a). One trench was excavated between two traces of the Calaveras fault (figure 2a). The trench did not cross the fault traces and evidence of faulting was not exposed in the trench.

#### Mission Fault

A segment of the Mission fault of Hall (1958) is depicted on the 1974 SSZ Map of the La Costa Valley quadrangle (figure 2a). A segment of the Mission fault mapped by Dibblee (1973) is depicted on the 1974 SS Map of the Calaveras Reservoir quadrangle (figure 2b).

The Mission fault of Dibblee (1973) is evaluated by Bryant (1980) in FER-105. Hart (1979) removed the Mission fault SSZ on the adjacent Niles quadrangle, based on the lack of evidence of Holocene offset. Herd (1978) did not observe evidence of Holocene or late Quaternary offset along the Mission fault of Hall (1958).

### 6. Conclusions

#### Calaveras Fault Zone

A. La Costa Valley quadrangle: The Calaveras fault zone in the La Costa Valley quadrangle is well-defined at the very southern part of the quadrangle and in the area north and south of Scotts Corner (figures 2a, 3a). The fault trace along the west side of Sunol Valley may be delineated by faceted, east-facing spurs in Cretaceous bedrock, but erosion may have formed these scarps. Herd (1978) maps the west branch Calaveras fault as concealed by late-Pleistocene and Holocene deposits. Much of the east branch Calaveras fault is concealed by landslide deposits or Holocene alluvium. However, a NOAA triangulation net indicates that consistent right lateral fault creep is occurring along the Calaveras fault just south of Scotts Corner (figure 3a).

Fault traces of Herd (1978), <sup>and Bryant (this report, figure 3a)</sup> adequately delineate the Calaveras fault in the <sup>Valley</sup> La Costa quadrangle.

B. Calaveras Reservoir quadrangle: The Calaveras fault zone in the Calaveras Reservoir quadrangle is complex and is obscured in parts of the quadrangle

because of the relatively rugged terrain and resulting high rates of erosion and landsliding. Right-lateral strike-slip faulting is indicated by the 5,000 foot right-lateral offset of Upper Penitencia Creek near Cherry Flat Reservoir (figure 3b). Well-defined fault features are sparse in the Calaveras Reservoir quadrangle and are characterized principally by linear drainages, troughs, and occasional sidehill benches and ~~scars~~ (figure 3b).

The west branch Calaveras fault of Dibblee (1973) and Cotton (1972) is not well-defined and geomorphic evidence of Holocene faulting was not observed by Herd (in press) or this writer (figures 2b, 3b). Fault traces mapped by Herd (in press), Bryant (figure 3b, this report), and selected traces of Dibblee (1973) adequately delineate the Calaveras fault.

C. Lick Observatory quadrangle: The Calaveras fault zone in the Lick Observatory quadrangle is wide and complex and forms a crude right-stepping pattern.

A closed depression associated with an east-facing scarp indicates Holocene faulting just north of Halls Valley (figure 3c). A complex, distributive zone of faulting characterizes the Calaveras fault zone south of Halls Valley (figures 2c, 3c). Well-defined fault features in San Felipe Valley and just south of San Felipe Valley are characterized by closed depressions, scarps, right-laterally deflected and offset drainages, sidehill troughs, and tonal lineaments in alluvium (figure 2c, 3c).

The east <sup>of the</sup> branches <sub>n</sub> Calaveras fault of Dibblee (1972a) southeast of Halls Valley are not well-defined and geomorphic evidence of Holocene faulting was not observed by Herd (in press) and this writer (figure 2c). The west branch Calaveras fault of Dibblee (1972a, 1972b) and the west branch Calaveras fault of Cotton (1972) are not well-defined and geomorphic evidence of Holocene faulting was not observed by Herd (in press) or this writer.

Fault traces of Herd (in press) and Bryant (figure 3c) adequately delineate the Calaveras fault in the Lick Observatory quadrangle.

Mission Fault

Herd (in press) did not observe evidence of Holocene or late-Quaternary offset along the Mission fault of Hall (1958) in the La Costa Valley quadrangle. Hart (1979) removed the Mission fault <sup>in the adjacent Niles quadrangle</sup> SSZ<sub>A</sub> because the fault did not meet the criteria of sufficiently active and well-defined.

7. Recommendations

Recommendations for zoning faults for special studies are based on the criteria of sufficiently active and well-defined (Hart, 1980).

A. La Costa Valley quadrangle: Zone for special studies well-defined traces of the Calaveras fault zone shown on figure 4a, based on mapping by Herd (1978) and Bryant (figure 3a, this report). The Calaveras fault along the east side of Sunol Valley is not well-defined in detail, but historic fault creep (NOAA, 1977) supports the decision to zone this segment of the fault. Delete the fault trace of Levish (1973) along the west side of Sunol Valley.

B. Calaveras Reservoir quadrangle: Delete the west branch Calaveras fault of Dibblee (1972a). Zone for special studies well-defined traces of the Calaveras fault shown on figure 4c, based on mapping by Herd (in press) and Bryant (figure 3c, this report). Delete the fault traces of Dibblee (1972b) and Cotton (1972) in the San Jose East quadrangle.

Mission Fault

Delete the trace of the Mission fault of Hall (1958) depicted on the La Costa Valley quadrangle. This fault is not well-defined and Hart (1979) deleted the SSZ on the adjacent Niles quadrangle.

8. Report prepared by William A. Bryant, April 10, 1981.

William A. Bryant

*I agree with  
recommendations.  
This segment of the Calaveras  
fault is more complex and  
difficult to evaluate than  
generally believed.  
EAB  
4/15/81*

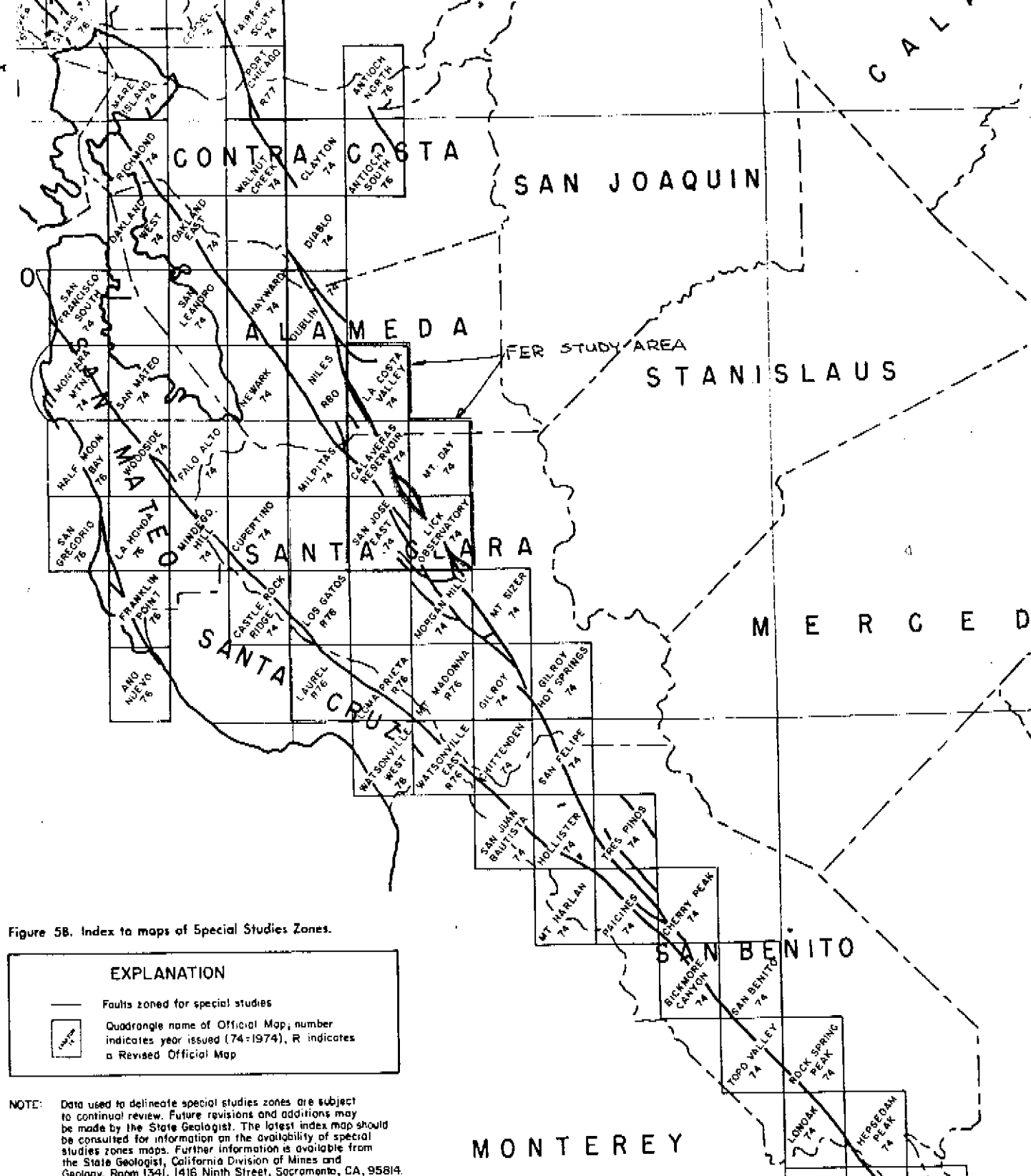


Figure 1 ( to FER-115 ). Location of Calaveras Area Fault zone (shown in green) to be evaluated in this FER. Map from Hart (1980, p. 13).